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(54) Ink supplying apparatus and ink jet recording apparatus having same.

(57) An ink supplying apparatus includes an ink flow passage connecting an ink storing portion for storing ink and an ejecting portion for ejecting the ink; a chamber disposed in the ink flow passage; a filter which divides the chamber into two spaces, one of which is provided with an ink entrance opening leading to the ink storing portion, and the other of which is provided with an ink exit opening leading to the ejecting portion; wherein the ink exit opening is disposed adjacent to the top wall of the chamber, with respect to gravity direction, and also, the ink exit opening is disposed above a level at which the ink entrance opening is disposed, with respect to direction.

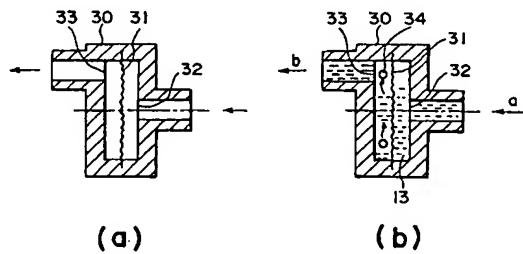


FIG. 4

EP 0 683 050 A2

## FIELD OF THE INVENTION AND RELATED ART

The present invention relates to an ink jet recording apparatus, in particular, an ink jet recording apparatus comprising an foreign matters removing apparatus for removing foreign matters.

Generally speaking, in an apparatus exemplified by an ink jet recording apparatus or the like, in which recording liquid is flowed through a liquid passage with a microscopic section, it is necessary to prevent the liquid from being insufficiently supplied due to the liquid passage blockage caused by foreign matters in the liquid (ink), that is, the foreign matters such as liquid (ink) deposit, bubbles, and the like which enter the liquid passage during the installation or removal of an ink container as an ink storing portion.

In particular, the ink jet recording apparatus is liable to suffer from this blockage caused by the foreign matters or ink deposit. This is because it has ejection orifices for ejecting ink droplets, and these orifices are extremely small relative to the internal diameter of the liquid passage, being thereby liable to be blocked.

Therefore, normally, in order to prevent the blockage of the ejection orifice portion, an foreign matters removing apparatus has been disposed in an ink supplying system for supplying the ink from the ink container, which is the ink storing portion, to the ejection orifices. This foreign matters removing apparatus is constituted of a chamber or the like provided with a filter which removes the microscopic foreign matters or bubbles.

A schematic view of the basic structure of such an ink jet recording apparatus is given in Figure 1, and a schematic section of the general structure of the filter chamber as a conventional foreign matters removing apparatus, which has been employed in this ink jet recording apparatus, is given in Figure 2. The ink jet recording apparatus depicted in Figure 1 is of a type that carries out a performance restoring operation by recirculating the ink.

Referring to Figure 1, a reference numeral 8 designates an ink container as an ink storing portion; 9, a gear pump for pressure-feeding the ink; 10, a power source for driving the gear pump; 11, a switch for controlling the driving of the pump; and a reference numeral 12 designates a recording head for ejecting the ink. It should be noted here that for the sake of simplification, the ink container 8 is schematically drawn with its top open, but the ink container 8 generally comprises an opening, through which the internal space thereof is in communication with the atmosphere.

A reference numeral 20 designates a filter chamber as the foreign matters removing apparatus; 21, an inflow tube as an ink supply tube, through which the ink is flowed into the foreign

matters removing apparatus; and a reference numeral 22 designates an outflow tube as an ink flow passage, through which the ink is led out of the filtering apparatus. This foreign matters removing apparatus 20 is disposed in both the ink passage leading from the ink container 8 to the recording head 12, and the ink flow passage returning to the ink container 8 from the recording head.

Referring to Figure 2, the foreign matters removing apparatus 2 comprises a filter 1, wherein a reference numeral 2 designates an ink entrance opening and a reference numeral 3 designates an ink exit opening.

In the above structure, as the ink 13 within the ink container 8 is initially supplied to the recording head 12, or when the gear pump 9 is activated to circulate the ink through the ink supplying system, the ink 13 from the ink container 8 enters the gear pump 9 by way of the ink supply tube 23, flows through the inflow tube 21, enters the foreign matters removing apparatus 20 disposed on the pump side through the ink entrance opening 2, passes through the filter 1, and reaches the recording head 12 by way of the ink exit opening 3.

In a structure such as the above structure, in which bubbles are removed by recirculating the ink, the ink is pressure-fed by the pump from the ink container to the recording head through the ink supply passage 23 constituting the outward passage, and the inflow tube 21,; and then, is further pressure-fed by the pump, being thereby returned from the recording head to the ink container through the outflow tube 22 constituting the return passage. Through such an ink recirculation, the bubbles existing in the outward ink passage, return ink passage, and recording head are returned to the ink container, where they are separated from the ink and released into the atmosphere.

Therefore, the filter of the foreign matters removing apparatus disposed in the aforementioned outward ink passage or return ink passage must allow the bubbles to pass when the gear pump 9 is activated.

On the other hand, when the ink is supplied from the ink container to the recording head through the outward ink passage during a recording operation, the ink is generally not pressure-fed by the pump, and instead, is supplied using the capillary force or the like of the ink in the recording head or the like. In this case, normally, the ink is supplied by the capillary force mainly from the ink exit tube 22 side, where flow resistance is smaller.

Also in this case, the bubble must not be allowed to pass through the filter of the foreign matters removing apparatus. This is because when the bubbles having entered the recording head exist in the ink passage on the ejection orifice side, ejection becomes unstable, and in the worst case,

the ejection may become impossible.

Having described the problems involving the foreign matters in the ink, the foreign matters removing apparatus illustrated in Figure 2 could not satisfy the prerequisites for the filter operated in the various modes such as the ones described above.

Referring to Figure 2(b), the ink 13 flowed in from the direction of an arrow mark a is sent to the foreign matters removing apparatus 20 comprising the filter 1 through an unillustrated inflow tube. The ink 13, which flows through the ink exit opening 3, is filtered by the filter 1 that does not pass the foreign matters or the like larger than 10  $\mu\text{m}$  in diameter. Because of the presence of this filter 1, the foreign matters 7 within the ink 13 accumulate on the arrow mark a side, which is the upstream side of the filter 1. In this case, the foreign matters do not flow into the side of an arrow mark b, which constitutes the outflow tube.

In such a conventional filter chamber 20 as the one described above, the aforementioned bubbles are liable to enter the ink flow passage (ink supply system passage), being thereby mixed into the ink, or remain on the upstream side of the filter chamber 20. Further, it is liable that even after the bubbles having accumulated on the upstream side of the filter chamber 20 pass the filtering portion, they rise due to their buoyancy and tend to linger at the point of ink flow stagnation, which develops at the top portion of the filter 1, on the downstream side, adhering subsequently to the filter within the filter chamber and reducing thereby the effective area of the filter. As a result, it is liable that the ink pressure is reduced to a point where unsatisfactory ink ejection occurs during the recording operation.

In recent years, it has become the main stream of the apparatus design to reduce the apparatus size. This has been accomplished by disposing the ink storing portion as well as the recording means on a carriage that scans the recording medium, instead of providing a long liquid supply route connecting the ink storing portion to the aforementioned recording means.

More specifically, the recording means and ink storing portion are in the form of cartridge, and can be individually mounted in, or removed from, the recording apparatus, even though they remain integrated while they are in the recording apparatus.

This arrangement has such an advantage that when the ink stops coming out of the recording means, the recording operation can be restarted just by replacing the ink storing portion. In other words, it reduces the running cost.

Further, this arrangement has a smaller component count compared to a structure in which the recording means and ink storing portion are not separable; therefore, it is easier to deal with the

used components like the ink depleted ink storing portion, reducing thereby the impact on the environment.

Presently, in addition to the demands for the aforementioned size reduction, there are increased demands for higher picture quality, which is accomplished by increasing the imaging resolution, and also, for higher recording speed. A frequently employed means for obtaining this high resolution is to make finer the ink ejecting nozzles generally provided within the recording means.

When the nozzles are made finer to increase the resolution, it is necessary to reduce the mesh size of the foreign matters screening filter disposed in the ink supply passage leading from the ink storing portion to the recording means. On the other hand, in order to increase the recording speed, it is necessary to increase the amount of the ink to be supplied per unit of time from the ink storing portion to the recording means. Thus, in order to increase both the resolution and recording speed, the pressure difference between the upstream and downstream sides of the film tends to increase. Therefore, the amount of pressure loss increases, which is liable to lead to response frequency loss.

As for effective means for suppressing this problem, the dimension of the filter in the filtering portion may be increased so that the effective area through which the ink passes can be increased. As for the structure of the filtering portion, a filter chamber is generally disposed at a predetermined point of the ink supply passage which connects the ink ejecting portion of the recording means and the ink storing portion. However, when the cartridge type design is employed for the recording means and ink storing means in order to reduce the apparatus size, there is a limit to the size to which the filter area is increased.

Further, when the total surface area of the walls constituting the flow passage increases due to the expansion of the filter chamber, it is more probable that gas enters the ink flow passage through the members constituting the walls, and forms bubbles therein, during an extended period of usage, even if a cartridge type ink storing portion (hereinafter, ink cartridge) and/or cartridge type recording means such as a recording head (hereinafter, recording head cartridge) are employed. This phenomenon is similar to the one that is frequently experienced when the recording means and ink storing portion are connected with a tube or the like as described before.

When these bubbles remain adhered to the filter and reduce the effective area of the filter, the response frequency drops, which leads to the unstable ejection. In other words, just increasing the dimension of the filter within the filtering portion is

not sufficient to maintain the steady ejection.

Normally, the removal of the bubbles adhering to the filter occurs when the ink is sucked through the ejection orifices of the recording means to restore the recording performance of the apparatus, and in order to remove completely the bubbles, a sucking apparatus with a large capacity is necessary, which goes against the trend of reducing the apparatus size.

In particular, when the structure illustrated in Figure 3 is employed, in which in order to reduce the apparatus dimension in the width direction, the ink flow passage is arranged in parallel to the gravity direction as it is in case the ink storing portion and ink ejecting means are disposed on the top and bottom sides, respectively, relative to the filtering portion, the aforementioned problematic phenomenon is more apparent. This is because the bubbles in the ink flow passage below the filter 1 are more liable to adhere to the filter 1 due to their buoyancy, and as a result, the bubbles in the filtering portion are more liable to grow and reduce the effective area.

On the other hand, the buoyancy (arrow mark C in the drawing) of the bubble 4 on the ink storing portion side of the filter 1 works against the force (arrow mark D) which is generated in the direction of passing the bubble through the filter during the performance restoring operation; therefore, the probability that the bubble 4 remains there increases.

#### SUMMARY OF THE INVENTION

The primary object of the present invention is to solve the aforementioned various problems, and thereby, to provide an ink jet recording apparatus capable of removing effectively the bubbles so that the ink is consistently and stably ejected, wherein the ink entrance opening of the foreign matters removing apparatus is disposed at a substantially central portion thereof, and the ink exit opening is disposed at the topmost portion thereof to smooth the ink flow, eliminating thereby the development of the spot where the bubbles tend to linger, so that the bubbles can be effectively removed.

Another object of the present invention is to provide an ink jet apparatus and an ink supplying apparatus which do not invite the increase in size and complexity thereof caused by the increase in the size or the like of the recording head cartridge provided with the ink flow passage.

Another object of the present invention is to prevent the deterioration of the recording image quality resulting from the instable ejection caused by the bubble adhesion to the filtering portion.

A further object of the present invention is to provide an ink jet apparatus and an ink supplying

apparatus which are capable of surely removing the bubbles even when an attempt is made to reduce the apparatus size in the width direction thereof by disposing the ink storing portion and ink ejecting means on the top and bottom sides of the filter, respectively, relative to the gravity direction.

According to an aspect of the present invention, there is provided an ink supplying apparatus comprising: an ink flow passage connecting an ink storing portion for storing ink and an ejecting portion for ejecting the ink; a chamber disposed in the ink flow passage; a filter which divides the chamber into two spaces, one of which is provided with an ink entrance opening leading to the ink storing portion, and the other of which is provided with an ink exit opening leading to the ejecting portion; wherein the ink exit opening is disposed adjacent to the top wall of the chamber, with respect to gravity direction, and also, the ink exit opening is disposed above a level at which the ink entrance opening is disposed, with respect to direction.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic perspective view of an example of conventional foreign matters removing apparatus.

Figure 2 is a schematic sectional view of an example of the filtering portion of the conventional foreign matters removing apparatus.

Figure 3 is a schematic sectional view depicting the shape of the filtering portion of the ink supplying system in the conventional small ink jet apparatus.

Figure 4 is a schematic sectional view of the first embodiment of the foreign matters removing apparatus according to the present invention.

Figure 5 is a schematic sectional view of a modification of the first embodiment of the foreign matters removing apparatus according to the present invention.

Figure 6 is a schematic sectional view of another modification of the first embodiment of the foreign matters removing apparatus according to the present invention.

Figure 7 is a schematic sectional view of the second embodiment of the foreign matters removing apparatus according to the present invention.

Figure 8 is a schematic perspective view of an embodiment of ink jet apparatus according to the present invention.

Figure 9 is a schematic sectional view of the third embodiment of the present invention, depicting the adjacencies of the carriage portion of the ink jet apparatus.

Figure 10 is an enlarged sectional view of the ink flow passage illustrated in Figure 9.

Figure 11 is a schematic sectional view of the fourth embodiment of the present invention, depicting the adjacencies of the carriage portion of the ink jet apparatus.

Figure 12 is an enlarged sectional view of the ink flow passage illustrated in Figure 11.

Figures 13(a) and 13(b) are schematic sectional views of a modification of the fourth embodiment.

Figures 14(a) and 14(b) are schematic sectional views of another modification of the fourth embodiment.

Figures 15(a) and 15(b) are sectional views of a modification of the embodiment illustrated in Figure 14.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the embodiments of the present invention will be described in detail referring to the drawings.

##### (Embodiment 1)

Figure 4 is a schematic sectional view of the first embodiment of the present invention, depicting a filter chamber 30 as the foreign matters removing apparatus. The foreign matters removing apparatus of this embodiment is disposed at the same location as the foreign matters removing apparatus 20 is disposed in the ink jet recording apparatus illustrated in Figure 1.

In Figure 4, a reference numeral 31 designates a filter which does not allow the foreign matters such as small foreign matter or the deposit from the ink to pass. It is consisted of mesh filter of SUS or the like, and is firmly fixed within the foreign matters removing apparatus, using thermal welding or the like.

A reference numeral 32 designates an ink entrance opening. When this foreign matters removing apparatus is disposed on the pump 9 side in the structure illustrated in Figure 1, this ink entrance opening is connected to the pump 9 with an inflow tube 21 or the like. When the apparatus is disposed on the ink container 8 side, it is connected to the ink liquid chamber of the recording head 12 with the inflow tube 21 or the like.

A reference numeral 33 designates an ink exit opening, which is disposed at the top portion of the foreign matters removing apparatus 30. In the case

of the structure illustrated in Figure 1, when the foreign matters removing apparatus is disposed on the pump 9 side, this ink exit opening 33 is connected to the ink liquid chamber of the recording head 12 with the outflow tube 22 or the like. When the apparatus 30 is disposed on the ink container 8 side, this ink exit opening 33 is connected to the ink container 8 with the outflow tube 22 or the like.

As for the positional relationship between the ink entrance opening 32 and ink exit opening 33, the ink exit opening 33 is disposed at the top portion of the filter mounting portion, relative to the gravity direction, and the ink entrance opening 32 is disposed below the ink exit opening 33 in the gravity direction, as shown in Figure 4.

In the above structure, when the gear pump 9 is activated to supply the ink 13 within the ink container 8 to the recording head 12, or to circulate the ink 13, the ink 13 within the ink container 8 is sent to the recording head 12 through the inflow tube 21, ink entrance opening 32 of the foreign matters removing apparatus 30 disposed on the pump side, filter 31, and ink exit opening 33.

Referring to Figure 4, during this ink movement, the bubbles in the ink and/or the bubble 34 within the foreign matters removing apparatus 30 collect at the top portion due to the buoyancy thereof, and then, all of them are moved to the recording head 12 side through the ink exit opening 33 disposed at the topmost portion of the filter 31, by the ink flow which is generated as the means for pressure-feeding the ink, such as the gear pump 9, is driven.

Also in the foreign matters removing apparatus 30 disposed on the ink container 8 side, the bubble 34 enters through the ink entrance opening 32, passes through the filter 31, and is delivered to the ink container 8 through the ink exit opening 33, just as it is on the pump 9 side.

Thus, the phenomenon that the effective area of the filter is reduced by the bubbles, which linger within the ink flow passage even after the completion of the performance restoring operation, can be prevented by changing the positional relationship between the two openings of the filter chamber from that of the conventional structure. This is because such a change causes the ink flow to change its direction within the filter chamber, which, in conjunction with the ink viscosity, suppresses the development of the point of ink stagnation where the bubbles linger.

Figure 5 shows a modification of the preceding embodiment. In this case, the ink entrance opening 32 of the filter chamber is differently disposed from the preceding embodiment. In Figure 5, the same components as those illustrated in Figure 4 are given the same designations to omit their descriptions. In Figure 5, the ink entrance opening 32 is

disposed below the center of the filter 31. This arrangement creates a stronger upward ink flow within the foreign matters removing apparatus 30 during the performance restoring operation. In other words, the ink flow component moving in the gravity direction in the filter chamber 30 increases; therefore, it becomes more difficult for the bubbles to linger in the top portion of the filter chamber 30, which in turn makes it possible to remove surely the bubbles.

It should be noted here that a tube connecting opening 36, that is, the external opening through which the ink flows out of the filter chamber, may be disposed so that it indirectly corresponds to the ink entrance opening 33 as shown in Figure 6.

#### (Embodiment 2)

Figure 7 is a schematic sectional view of the second embodiment of filter chamber as the foreign matters removing apparatus according to the present invention. In Figure 7, the same components as those illustrated in Figure 4 are given the same designations to omit the descriptions. In Figure 7, a valve 35 is such a valve that comes in contact with the filter 31 as shown in Figure 7(b) when the amount of the ink flow per unit of time at the filtering portion increases while the ink is circulated by the pump 9.

Compared to the structure with no provision of the valve 35 in the foreign matters removing apparatus 30, the provision thereof can increase the pressure difference between the front and back sides of the filter 31 while the ink is circulated for the recovery operation; therefore, the ink flow with a higher pressure can be generated at the filter 31 by the gear pump or the like, whereby the bubbles are more efficiently passed through the filter 31.

In this case, it is more preferable for the ink entrance opening 32 to be disposed at substantially the middle portion of the foreign matters removing apparatus than at the bottom portion thereof. This is because such disposition of the ink entrance opening 32 allows the valve to move smoothly in response to the amount of the ink flow within the ink supply passage, and also, allows the valve to cling surely to the filter 31 by the entire surface thereof, so that the bubble 34 adhering to the filter surface can be easily removed.

Also, the disposition of the ink exit opening 33 at the top portion of the foreign matters removing apparatus 31 makes it possible to send the bubble 34 completely out of the filter chamber without inviting it to linger therein.

As is evident from the above description, when the ink entrance opening of the foreign matters removing apparatus is disposed at a substantially middle portion of the foreign matters removing

apparatus, or below the middle thereof, and also, when the ink exit opening is disposed at the top portion of the filter of the foreign matters removing apparatus, it is possible to remove satisfactorily the foreign matters within the ink. In particular, the bubbles within the ink or the bubbles accumulated within the foreign matters removing apparatus can be completely removed. As a result, it is possible to provide an ink jet head capable of ejecting the ink constantly and stably.

Next, a description is given as to a case in which the present invention is applied to the filter chamber of a structure in which the ink storing portion is mounted on a carriage for mounting recording means which records images as it scans the surface of the aforementioned recording medium.

To begin with, a schematic perspective view of an exemplary ink jet apparatus IJRA comprising the recording means and ink storing portion, which are mounted on the carriage, is given in Figure 8. In Figure 8, a reference numeral 41 designates an ink cartridge as the ink storing portion, and a reference numeral 48 designates a carriage on which the ink cartridge 41 and a recording head cartridge 42 as the recording means, which will be described later, are removably mounted.

A reference numeral 49 designates a lead screw for making the carriage 48 scan a recording medium 51 such as a sheet of recording paper or plastic material, and a reference numeral 50 designates a guide rail for guiding the scanning movement of the carriage 48. The movement of the lead screw 49 is linked to the forward and backward rotation of a driving motor 55 by way of gears 53 and 54, wherein a spiral groove 52 cut in the lead screw 49 is in engagement with an unillustrated engagement portion provided on the carriage 48, and therefore, the carriage 48 is driven to scan in the longitudinal direction of the apparatus by the driving motor 55. The recording medium 51 is conveyed by a platen roller 56.

Further, performance restoring means for restoring the performance of the ejecting portion provided in the recording means, which will be described later, is disposed adjacent to the path of the recording medium 51. This performance restoring means comprises a cap member 60 for capping the ejection orifice portion (unillustrated) of the recording head cartridge, and a sucking means 61 for restoring the performance of the ejecting portion by sucking it through an internal opening (unillustrated) provided within the cap member 60. To this sucking means, the driving force from the driving motor 55 is transmitted by well-known transmitting means comprising a gear 62, a switching clutch, and the like.

As for the vertical and related movements of the cap member 60, it is caused by the driving force transmitted by way of a gear 63 or the like, wherein, in order to suck the ejection orifices to restore their performance, and in order to slow the ink evaporation, the cap member 60 is placed airtightly in contact with the surface where the ejection orifices are present.

Further, the aforementioned performance restoring sucking operation can not only restore the performance of the clogged ejection orifices, but also discharge the ink contained in the ink flow passage portion between the ink cartridge and ejecting portion by changing the amount of the ink to be sucked, so that the microscopic foreign matters, bubbles, or the like can be removed from the filtering portion as well as the ink flow passage. This ink flow passage performance restoring operation is carried out with regular intervals, or is compulsively carried out whenever determined to be necessary by a user, so that preferable print quality can be maintained.

The aforementioned capping and performance restoring sucking operation are carried out at the correspondent locations while the carriage 48 is in the appropriate region on the home position side. Also, these operations are performed, independently or in combination, using well-known timing and sequence, or optionally.

#### (Embodiment 3)

Given in Figure 9 is a schematic sectional view of the third embodiment of the present invention, depicting a recording head cartridge and an ink cartridge, which are on the carriage of an ink jet recording apparatus. Given in Figure 10 is an enlarged sectional view of an ink flow passage 44 constituting the ink supplying system (ink supplying apparatus) illustrated in Figure 9. The arrow mark A in the drawing indicates the gravity direction.

Referring to Figure 9, a reference numeral 41 designates an ink cartridge, which is an ink storing portion for storing the ink, and a reference numeral 42 designates a recording head cartridge as the recording means for recording images using the ink supplied from the ink cartridge 41.

A reference numeral 43 designates the ejecting portion comprising nozzles (ejection orifices) for ejecting the ink, and a reference numeral 44 designates an ink flow passage connecting the ink cartridge 41 and ejecting portion 43. A reference numeral 45 designates a joint portion which watertightly connects the interior of the ink cartridge to the ink flow passage 44 when the ink cartridge 41 is mounted, and which seals the ink cartridge 41 when the ink cartridge 41 is removed. In this em-

bodiment, this joint portion 45 is formed of elastic material, like rubber, wherein the tip of the ink flow passage 44 is connected to this joint portion 45 of elastic material using a well-known conventional method.

The ink flow passage 44 comprises a double-back flow passage portion 47 containing a filter 46, and the other ink flow passage portions connecting this double-back flow passage portion 47 to the ink storing portion and ejecting portion, respectively. In this embodiment, this double-back flow passage constitutes the filter chamber.

It should be noted here, though it is not going to be detailed, that in this embodiment, the pressure at the nozzle portion of the ink cartridge 41 is set below the atmospheric pressure with the provision of a well-known pressure regulating mechanism such as a multi-chamber structure comprising a connecting portion for forming a meniscus.

The aforementioned ink cartridge 41 and recording head cartridge 42 are structured so that they can be removably mounted on the carriage 48. This carriage 48 is supported by a guide shaft 49, which is a rail provided in the ink jet apparatus, and is moved on the guide shaft for scanning during the recording operation. In this embodiment, the recording medium 50 is placed perpendicular to the gravity direction, whereas the ink ejected from the nozzle 43 flies in parallel to the gravity direction.

Next, the flows of the ink and bubbles in this embodiment will be described. As the ink is sucked through the ejection orifice by the aforementioned performance restoring apparatus or the like, the ink within the ejecting portion 43 is sucked out, and a new supply of ink from the ink cartridge 41 is filled into the ejecting portion 43.

The ink flow at this time will be described referring to Figure 10. In Figure 10, an ink flow passage 44a is a connecting passage leading to the ink cartridge 41 storing the ink, and the bottom end of an ink flow passage 44b is a connecting passage leading to the recording head cartridge 42 comprising the ejecting portion. As for the sectional configuration of the ink flow passage, it is bent; more specifically, it doubles back at the top and bottom portions of the filter chamber 47. Therefore, the ink flow passage 44 is structured to have a bent portion at a point where the ink flow passage 44a connects to the double-back flow passage 47, and at a point where the double-back flow passage 47 connects to the ink flow passage 44b; in other words, the double-back flow passage is disposed between the two bent portions.

The ink flows down from the ink cartridge 41 side through the ink flow passage 44a in the gravity direction; flows into the adjacencies of the bottom portion of the double-back flow passage 47 in

which the filter 46 is disposed; and thereafter, flows through the double-back flow passage 47 in the direction opposite to the gravity direction, that is, in the direction of the buoyancy indicated by an arrow mark B in the drawing. Then, the ink enters the ink flow passage 44b from the adjacencies of the topmost portion of the double-back flow passage 47; flows downward again in the gravity direction; and reaches the ejecting portion 43 side where the nozzles are. This ink flow described above results from the pressure difference between the pressure generated at the ejecting portion by the sucking means 61 and the cap 60 adhering airtightly to the ejecting portion, and the pressure working on the ink cartridge.

On the other hand, a bubble larger than a certain size moves along with the aforementioned ink flow, and in this embodiment, the ink flow passages 44a and 44b are made relatively small, and given a uniform cross section across their length, so that this bubble movement can be enhanced. Therefore, the speed of the ink flow increases within the ink flow passages 44a and 44b, detaching easily the bubbles adhering to the flow passage walls, and thereby, making it easier for them to be discharged from the ejecting portion during the performance restoring operation.

As for the filter chamber 47 constituted of the double-back flow passage, it extends in the gravity direction, being connected to the ink flow passages 44a and 44b at the bottom and top portions, respectively. In this embodiment, the opening portions are disposed at the bottommost and topmost portions, respectively. This arrangement is made to give the ink flow passage 44 a smooth flow passage structure in which the ink flow stagnation is unlikely to occur; therefore, the loss of the sucking force generated by the performance restoring system can be reduced, increasing subsequently the force working on the bubbles.

Further, the filter chamber is structured so as to allow the ink to flow in the direction of the buoyancy working on the bubbles; therefore, not only the bubbles clinging to the filter 46 are more easily detached, but also, the bubbles within the ink flow passage 44a can also be more easily passed through the filter 46, during the performance restoring operation. Consequently, the bubble removal from the filtering portion by the performance restoring sucking operation can be rendered more reliable.

Further, in this embodiment, the filter is disposed in parallel to the direction of the ink flow within the filter chamber 47 constituted of the double-back flow passage; therefore, the effective area of the filter can be increased without increasing the cross section of the double-back flow passage, relative to the direction of the ink flow. With this

arrangement, it is possible, without increasing the apparatus size, to decrease the pressure loss which occurs when the ink passes through the filter 46 during the recording operation or the like. Therefore, even when the amount of the ink supply per unit of time is increased in order to increase the recording speed, or the mesh size of the filter is reduced in order to obtain higher resolution, the ink supplying performance does not deteriorate.

#### (Embodiment 4)

The fourth embodiment of the present invention is given in Figures 11 and 12. Figure 11 is a schematic sectional view of a recording head cartridge and an ink cartridge, which are on the carriage of an ink jet recording apparatus. Figure 12 is an enlarged sectional view of the ink flow passage 44 illustrated in Figure 11.

Referring to Figure 11, the structure of this embodiment is different from the aforementioned embodiment in that the filter chamber 47b is tilted relative to the gravity direction (or the horizontal direction perpendicular to the gravity direction).

The other structures are the same as those in the third embodiment. As shown in Figure 12, the ink flow passage 44a and 44b are relatively narrow, having a uniform cross section across their length; therefore, the speed of the ink flow is increased within the ink flow passages 44a and 44b. They are connected to the bottommost and topmost portions, respectively, of the filter chamber 47b constituted of the double-back flow passage.

When the filter chamber 47 is slanted relative to the gravity direction, or the horizontal direction perpendicular to the gravity direction, not only can the total number of the bent portions in the longitudinal sectional view be decreased, but also, the overall length of the ink flow passage itself can be shortened. As is evident from Figures 10 and 12, when the longitudinal sectional areas of the ink flow passages 44 in the first and this embodiment are compared,  $L2 + L3 + L4 > L2' + L3' + L4'$ . In other words, the total flow passage length of this embodiment is shorter than that of the first embodiment. Consequently, using the structure of this embodiment further reduces the total flow passage resistance, whereby not only does it become easier to increase the recording speed and resolution, but also, it becomes possible to reduce the loss of the force which works on the bubbles in the filtering portion during the performance restoring operation. Therefore, the more complete bubble removal by the performance restoring sucking operation can be assured.

Further, the reduction of the total wall surface area decreases the probability of the gas permeation into the ink flow passage, which is frequently



observed during a prolonged usage.

It is also discovered that when the foreign matters removing apparatus is structured like this embodiment in which the filter 46 is disposed so as to extend in the direction of the slanted flow passage 47b, it is possible to make it more difficult for the microscopic bubbles to cling to the filter 46, and also, it becomes easier to remove them from the flow passage. As for the microscopic bubbles mentioned above, it is more liable for them to develop when surfactant is mixed into the ink as means for obtaining picture quality of a higher degree. Since the cross sections of these microscopic bubbles are extremely small, the ink pressure does not satisfactorily affect them; in other words, it is rather difficult to force them through the filtering portion. In particular, when the bubbles with an approximately the same size as the mesh size of the filter adhere to the filter, they tend to remain there in stable condition due to the surface tension or the like; therefore, it is difficult to remove them, reducing consequently the effective area of the filter.

However, when the structure according to this patent application is employed, the double-back ink flow passage 47b and filter 46 are disposed with a certain angle relative to the gravity direction or the horizontal direction perpendicular to the gravity direction; therefore, the buoyancy of the bubbles effects in the direction of detaching them from the filter.

Consequently, even when the ink is flowing, it is more difficult for the bubbles to adhere to the filter, and also, it is easier for them to separate therefrom. At the same time, it is easier for them to move along the flow passage wall to the top space of the filter chamber constituted of the double-back ink flow passage, where they, the microscopic bubbles, join together, and thereby, grow into larger bubbles. Thus, it becomes possible to remove even the microscopic bubbles in the same manner as the ordinary bubbles, and thereby, to prevent the effective filter area from being reduced by the bubbles. As a result, high quality images can be obtained.

#### (Other Embodiments)

A modification of the fourth embodiment is shown in Figure 13. Figure 13(a) is a schematic sectional view of the ink flow passage 44, and Figure 13(b) is a schematic sectional view of the ink flow passage 44, at a sectional line P - P indicated in Figure 13(a). In this embodiment, a trapezoidal configuration illustrated in Figure 13(b) is employed for the double-back flow passage so that the cross section of the filter chamber constituting a portion of the ink flow passage 44 gradu-

ally decreases toward the top.

With the employment of this structure, the speed of the ink flow drops once as the ink enters from the ink flow passage 44a into the filter chamber, and thereafter, gradually increases toward the top of the filter chamber 47b, becoming fastest at the topmost portion of the filter chamber 47b, where the bubbles are most likely to collect.

This effect, in conjunction with the aforementioned effects of the preceding embodiment, further reduces the force necessary to pass the bubbles through the filter 46; therefore, the force necessary to be applied to the filtering portion, that is, the force required of the sucking means, decreases. Thus, this embodiment allows the apparatus size to be further reduced, and also allows the mesh size to be further reduced, so that the nozzle size can be further reduced to improve the image resolution. It should be noted here that even though the trapezoidal configuration is employed in this embodiment, the configuration is not limited to this one, and may be optionally selected as long as it reduces the cross section of the double-back flow passage portion toward the top.

Figure 14 illustrates another modification for increasing the ink flow speed adjacent to the top portion of the double-back ink flow passage 47b, where the double-back ink flow passage 47b is connected to the top end opening of the ink flow passage 44b. In this modification, a valve mechanism is added to the structure described in the foregoing in order to increase further the ink flow speed during the performance restoring operation. Figure 14(a) is a schematic sectional view of the ink flow passage 44, and Figure 14(b) is a schematic sectional view of the ink flow passage 44, at a sectional line Q - Q indicated in Figure 14(a).

Referring to Figure 14(a), this structure comprises a valve 57 which remains separated from the filter 64 during an actual recording operation, that is, while the performance restoring operation is not carried out. The valve 57 is placed in the filter chamber, on the ink flow passage 44a side of the filter 46, that is, on the ink storing portion side. It is a 10 - 100  $\mu$ m thick sheet of resin material such as PPS.

As for the configuration and material for the valve 57, they are not limited to those described in the foregoing as long as they can provide such elasticity that does not allow the valve 57 to come in contact with the filtering portion when the ink is slowly flowing, as it is during the actual recording operation, and allows it adhere to the filter so that the effective area of the filter is reduced when the pressure difference between the upstream and downstream sides of the filter is large, as it is during the performance restoring operation.

With the employment of this structure, it is possible to generate the pressure difference and pressure strong enough to pass reliably the bubbles through the filter 46 during the performance restoring operation, without deteriorating the print quality during the recording operation.

In the case of the structure illustrated in Figure 14, it is highly probable that the bubbles, which invade into the gap between the filter 46 and valve 57 and adhere to the filter 46, becomes difficult to remove during a routine performance restoring operation; therefore they are liable to reduce the effective area of the filter during the recording operation, or to prevent the valve from functioning effectively during the performance restoring operation. Thus, it is preferable that the valve is structured as described below.

Figure 15 shows such a valve structure. Figure 15(a) is a schematic view of such a valve as seen from the direction of Q indicated in Figure 14, and Figure 15(b) is a schematic sectional view of the same valve, at a sectional line R - R indicated in Figure 15(a). In this structure, a grooved portion 59 is provided on the valve 58. This structure is particularly effective when the bubbles are lodging between the filter and valve due to the surface tension or the like. The presence of the grooved portion 59 enhances the upward movement of the bubbles in the filter chamber, in conjunction with the buoyancy of the bubbles themselves, and the surface tension which works to sphere the bubbles; therefore, the bubbles can be discharged from between the filter and valve.

As described hereinbefore, the present invention can be employed in a device having only a small space available for the placement of the filter chamber, such as the aforementioned carriage on which the recording means and ink storing portion are mounted, wherein since the structure employed is such that the ink is allowed to flow in the direction in which the buoyancy of the bubbles works, not only the detachment of the bubbles adhering to the filter becomes easier, but also, it becomes easier for the bubbles within the ink flow passage to pass through the filter. Therefore, the bubble removal by the performance restoring operation can be rendered more reliable.

Further, a double-back flow passage portion constituting a portion of an ink flow passage portion is disposed between two bends of the ink flow passage in a manner to intersect with the gravity direction, and a filter is disposed in a manner to extend in the same direction as this ink flow passage portion between these two bends extends, that is, in a manner to extend in the direction of the ink flow; therefore, the effective area of the filter can be increased without increasing the cross section of the in flow passage, relative to the ink flow

direction, as it is increased when a conventional filtering portion is employed. Consequently, the pressure loss which occurs when the ink passes through the filter during the recording operation can be reduced, affording an increased amount of the ink supplied per unit of time for high speed printing, and also, ink supply capacity does not deteriorate even when the mesh size of the filter is reduced to increase the print resolution. In addition, the loss of the force which works on the bubbles during the performance restoring operation can be reduced.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

An ink supplying apparatus includes an ink flow passage connecting an ink storing portion for storing ink and an ejecting portion for ejecting the ink; a chamber disposed in the ink flow passage; a filter which divides the chamber into two spaces, one of which is provided with an ink entrance opening leading to the ink storing portion, and the other of which is provided with an ink exit opening leading to the ejecting portion; wherein the ink exit opening is disposed adjacent to the top wall of the chamber, with respect to gravity direction, and also, the ink exit opening is disposed above a level at which the ink entrance opening is disposed, with respect to direction.

## Claims

1. An ink supplying apparatus comprising:
  - an ink flow passage connecting an ink storing portion for storing ink and an ejecting portion for ejecting the ink;
  - a chamber disposed in said ink flow passage;
  - a filter which divides said chamber into two spaces, one of which is provided with an ink entrance opening leading to the ink storing portion, and the other of which is provided with an ink exit opening leading to the ejecting portion;
  - wherein said ink exit opening is disposed adjacent to the top wall of said chamber, with respect to gravity direction, and also, said ink exit opening is disposed above a level at which said ink entrance opening is disposed, with respect to direction.
2. An ink supplying apparatus according to Claim 1, wherein said chamber comprises:
  - a sheet member disposed between said filter and ink entrance opening, adjacent to

said filter; and

said sheet member faces said ink entrance opening, and covers a part of said filter when the amount of the ink flow per unit of time is more than that for a recording operation.

3. An ink supplying apparatus according to Claim 1, wherein said ink storing portion is disposed above said ejecting portion;

said chamber extends in the direction which intersects with the direction perpendicular to the gravity direction; and

said filter is disposed in parallel to the direction in which said chamber extends.

4. An ink supplying apparatus according to Claim 3, wherein the direction in which said chamber extends also intersects with the gravity direction.

5. An ink supplying apparatus according to Claim 3, wherein said ink flow passage comprises a first ink flow passage connecting said chamber and ink storing portion, and a second ink flow passage connecting said chamber and ejecting portion; and

said first and second ink flow passages extend from said chamber at an acute angle.

6. An ink supplying apparatus according to Claim 3, wherein the cross section of said chamber is larger at the downward portion thereof, relative to the gravity direction, than at the portion adjacent to said ink exit opening, the cross section being in parallel to a plane perpendicular to the direction of the ink flow.

7. An ink supplying apparatus according to Claim 5, wherein a valve is disposed between the filter of said chamber and the opening of said first flow passage, and the total area of said valve is smaller than the total area of said filter.

8. An ink supplying apparatus according to Claim 5, wherein a groove is provided on said valve, on the filter side.

9. An ink jet recording apparatus comprising an ink flow passage connecting an ink storing portion for storing ink and an ejecting portion for ejecting the ink, comprising further:

a chamber disposed at a predetermined point of said ink flow passage, comprising a filter which divides said chamber into two spaces, one of which being provided with an ink entrance opening leading to said ink storing portion, and the other of which being provided with an ink exit opening leading to said ejec-

ting portion;

wherein said ink exit opening is disposed adjacent to the top wall of said chamber, relative to the gravity direction, and said ink exit opening is disposed at a higher point, relative to the gravity direction, than said ink entrance opening.

10. An ink jet recording apparatus according to Claim 9, wherein the wall facing said filter intersects with the gravity direction.

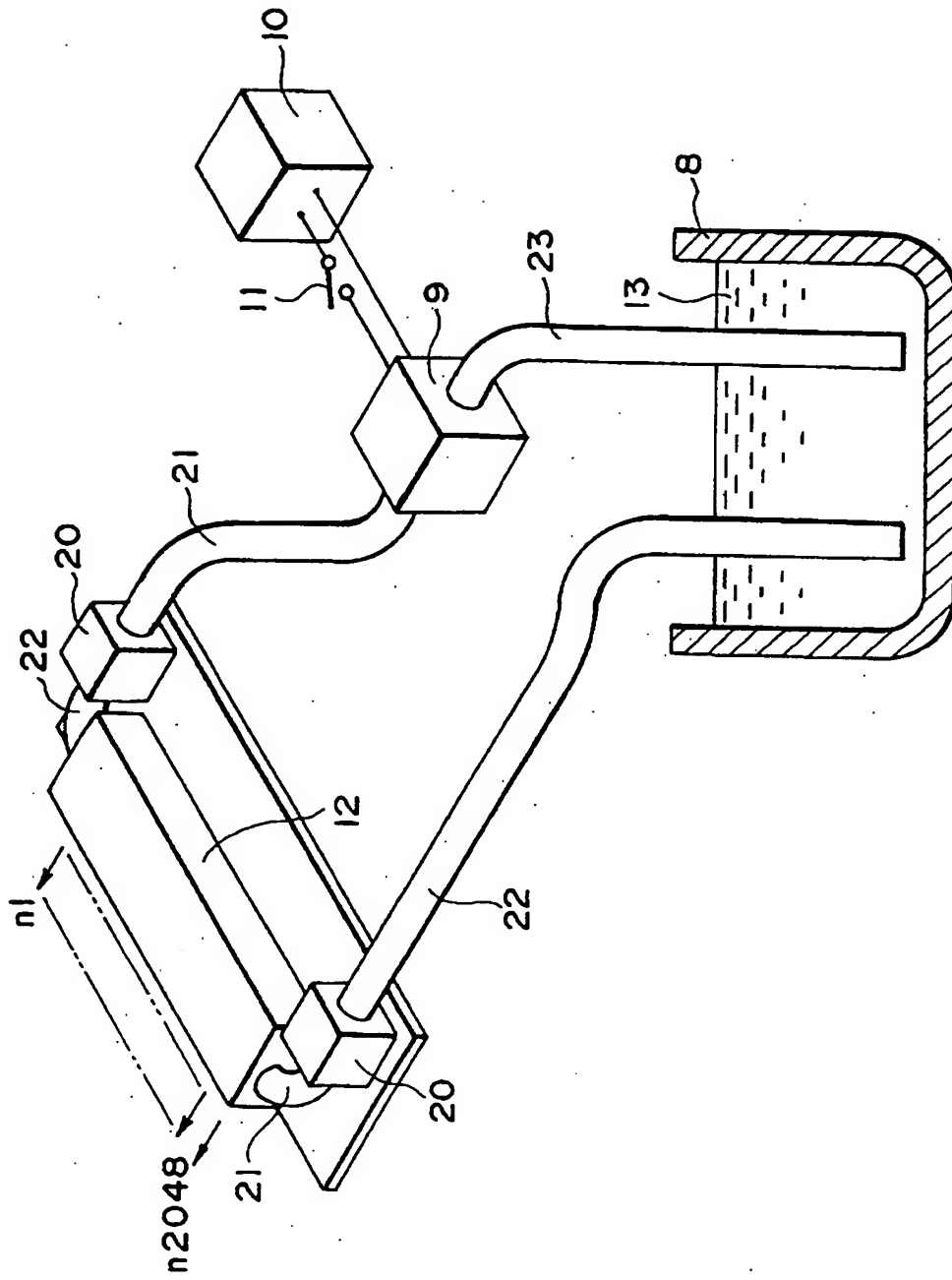


FIG. 1

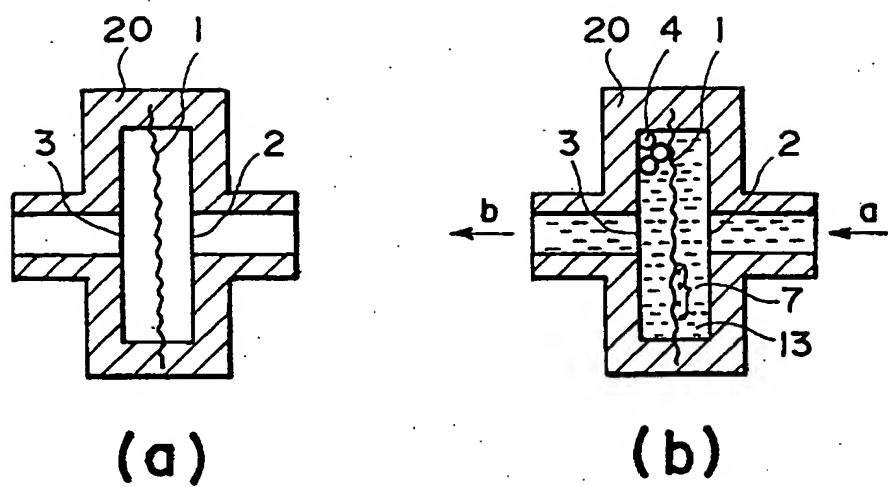


FIG. 2

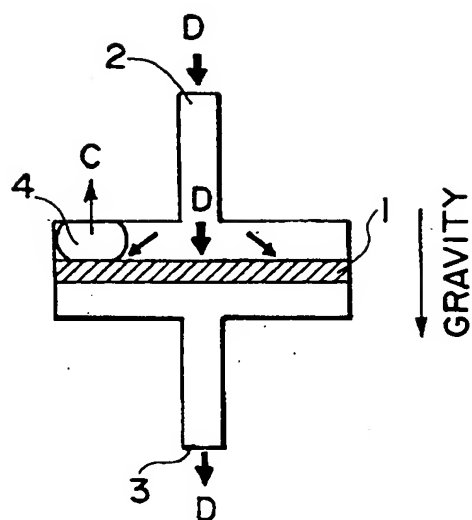


FIG. 3

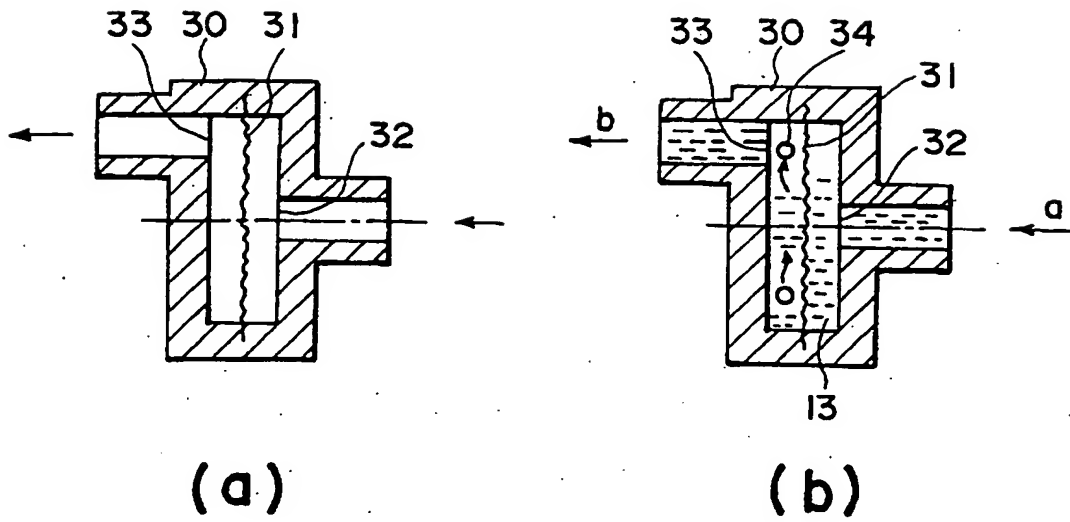
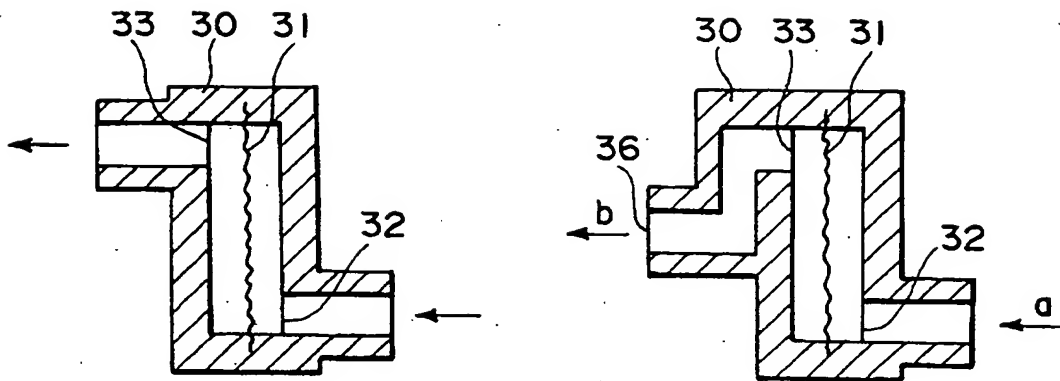
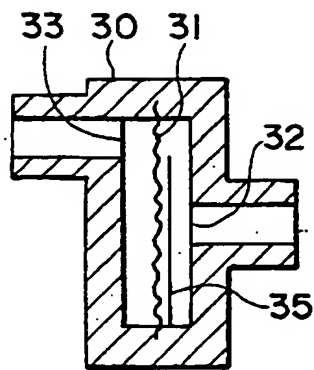
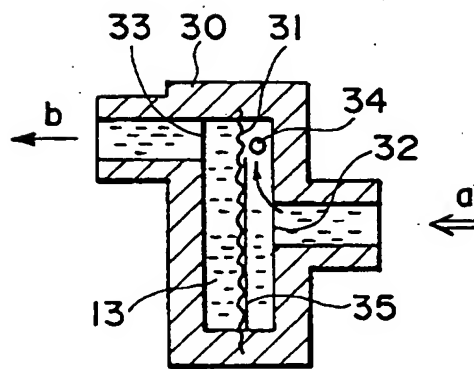


FIG. 4





(a)



(b)

FIG. 7

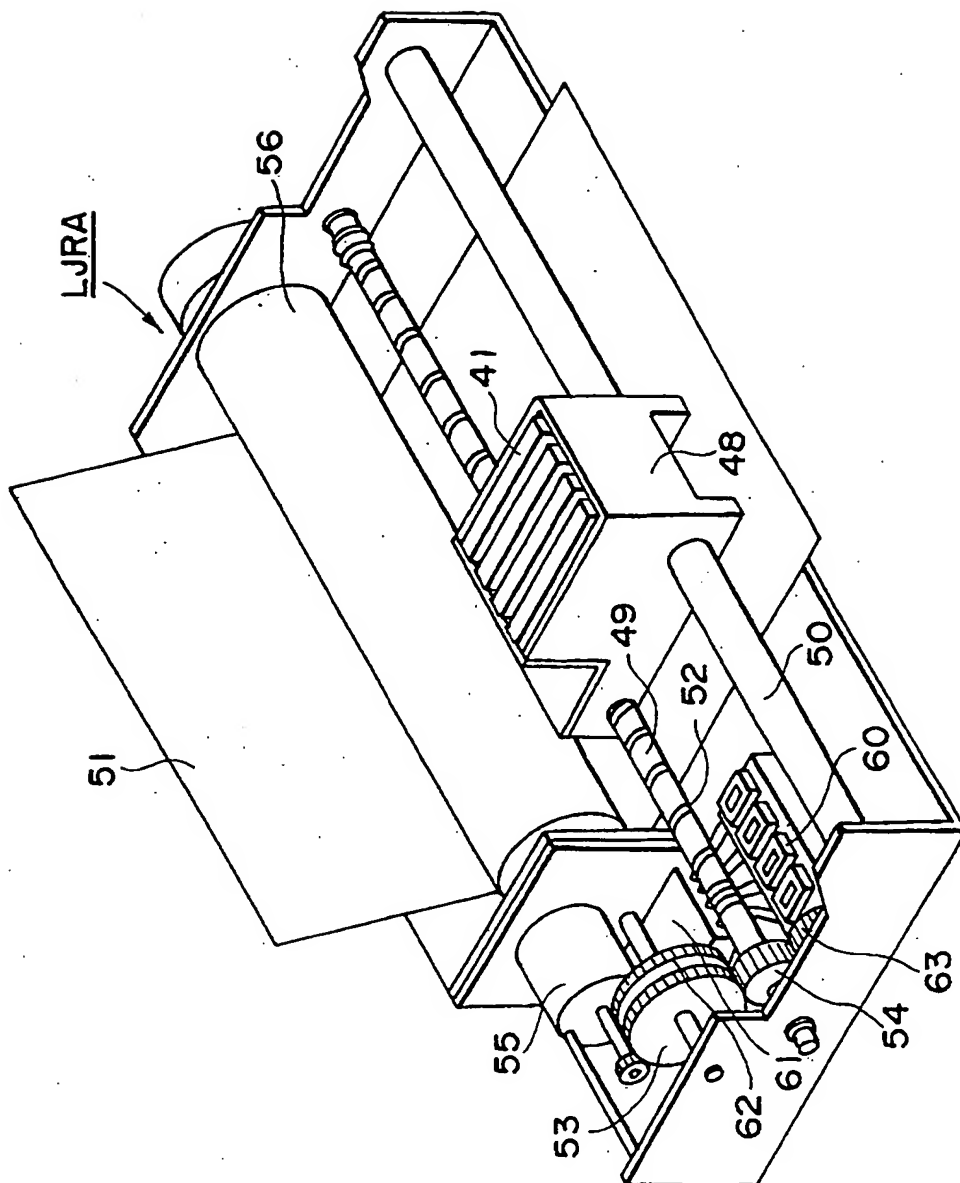


FIG. 8



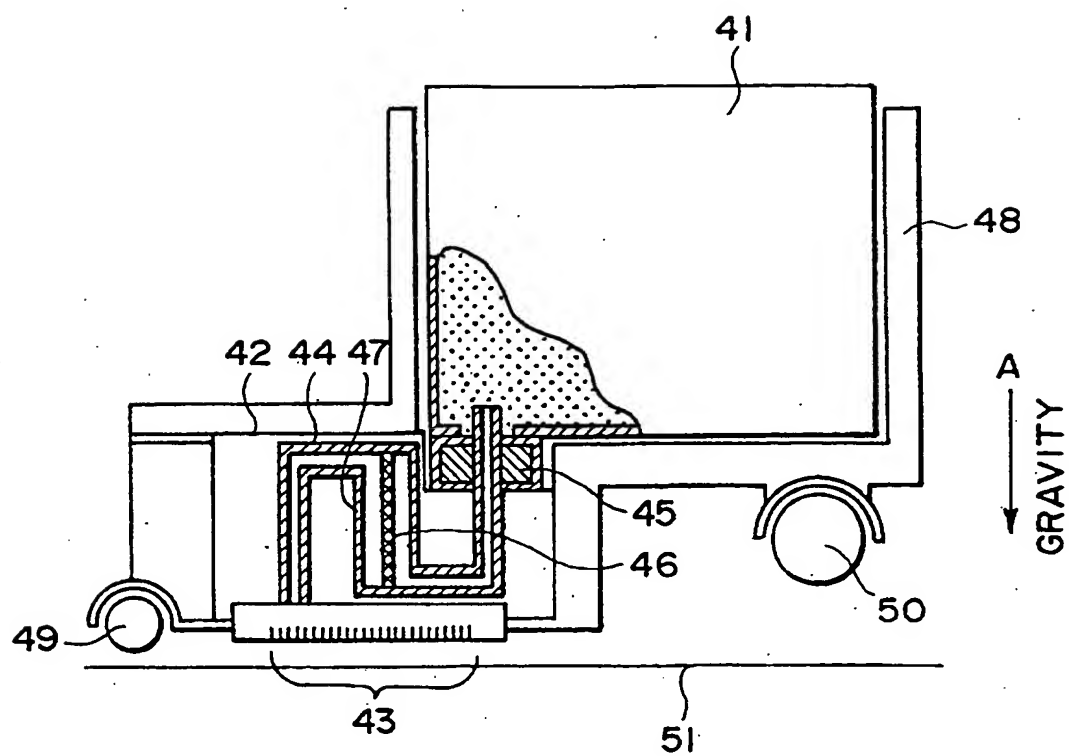


FIG. 9

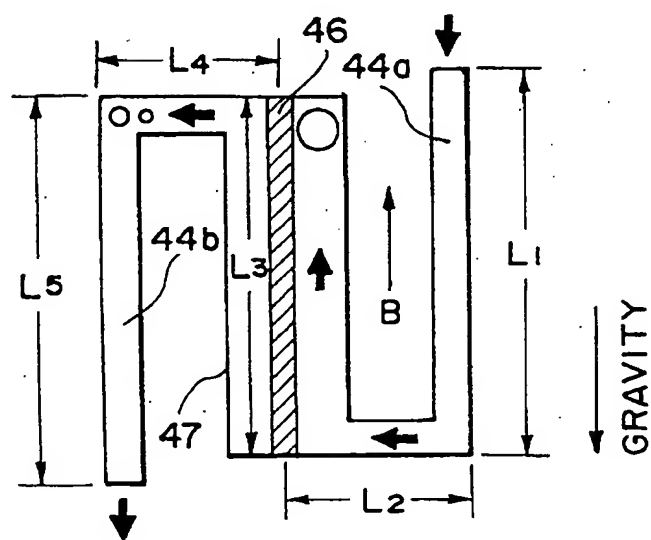


FIG. 10

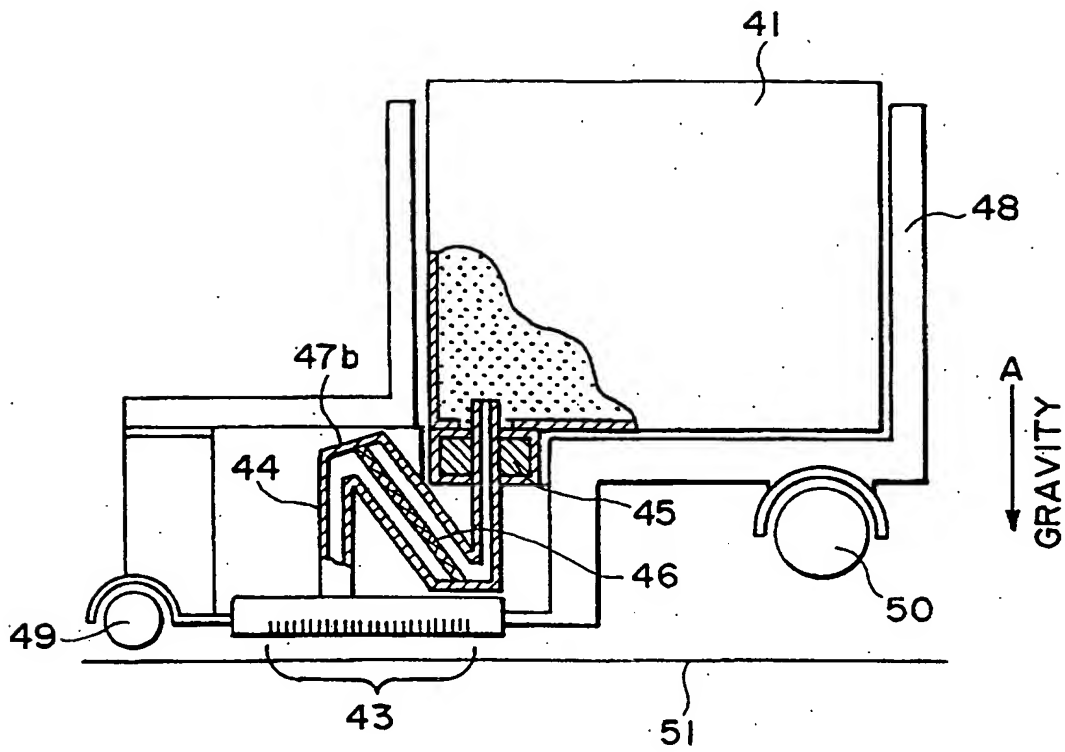


FIG. 11

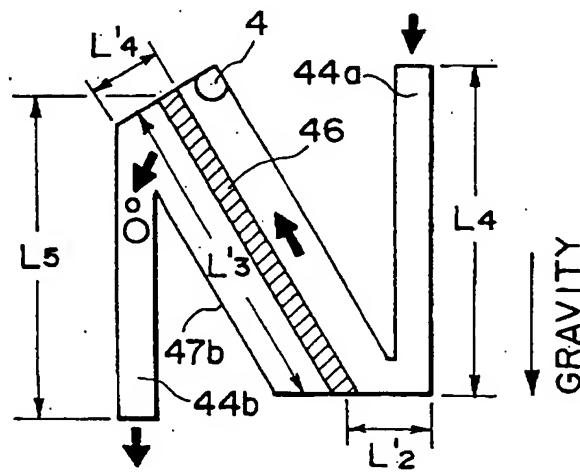


FIG. 12

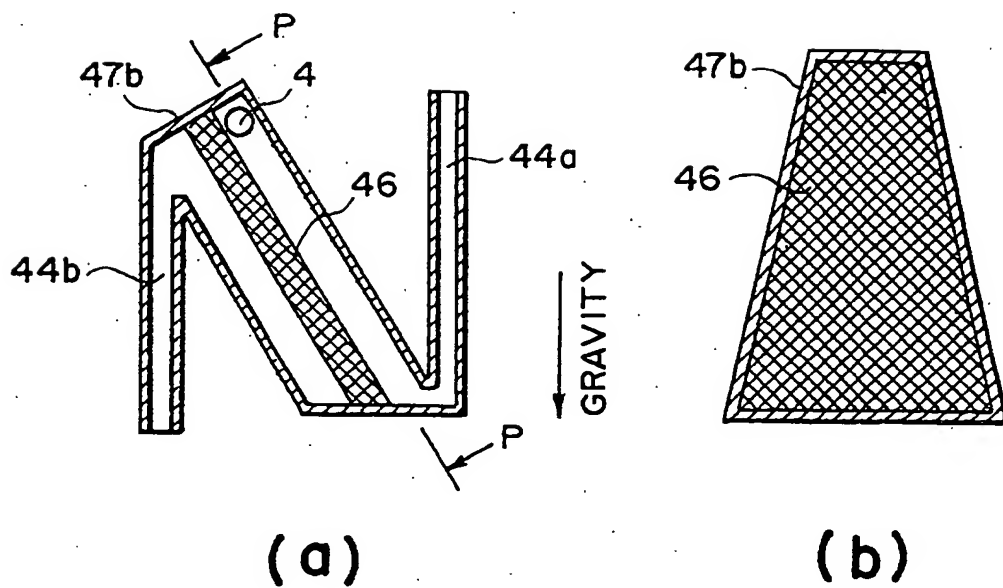


FIG. 13

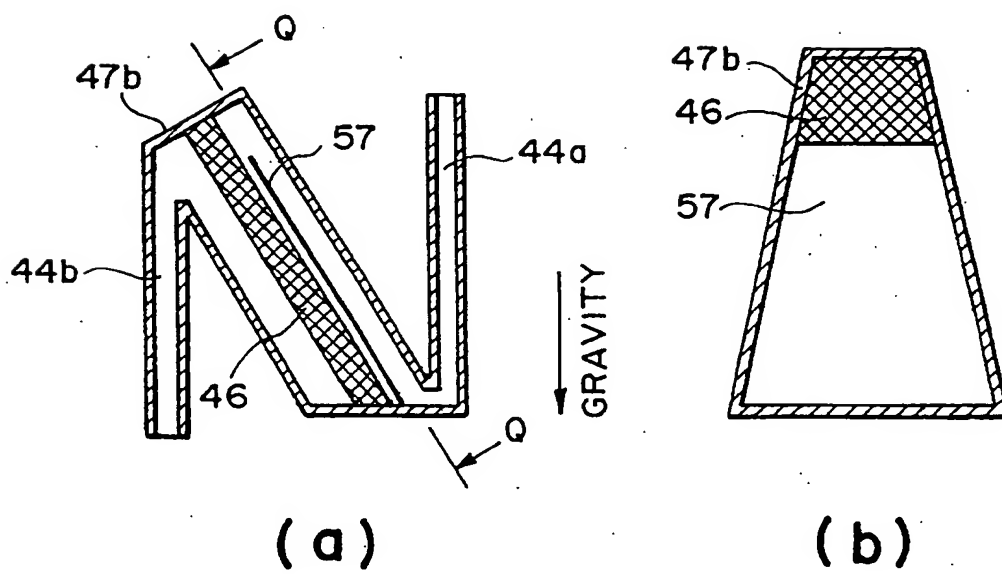
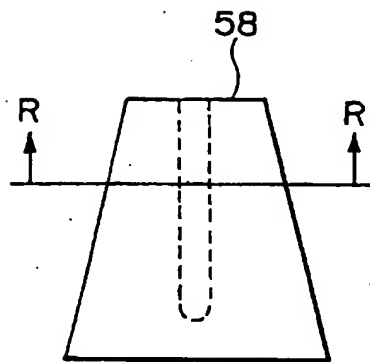
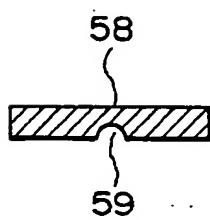


FIG. 14



(a)



(b)

FIG. 15